All About EV Homologation vD0

A complete explanation and guide for homologation

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Introduction

Homologation refers to all the approvals an automotive manufacturer must attain before they can proceed with marketing and selling the vehicle. It comprises various stages from component level approval all the way until the complete vehicle compliance.

These approvals are made to ensure safety, control over pollution etc. The homologation process for various categories of vehicles is different. EV companies although are in the two or three-wheeler segment, hence this document will pertain more towards the aforementioned categories.

The homologation process is one which startups or new product companies must keep in mind while planning on the product development phase with respect to both technical and commercial aspects. The parts/vehicle must be compliant with the standards and follow the CMVR. The designs should be made considering their conformity with the standards with all boundaries and worst cases considered.

The same goes for financial aspects. The company should know exactly which category their vehicle falls under and accordingly plan their finances and keep a 30% buffer for the same as a thumb rule.

The two major Institutions for homologation are the following.

- Automotive research association of India (ARAI)
- International centre for automotive technology (iCAT)

Vehicle Categories

- L1 category vehicles are two-wheelers with a top speed less than 25 km/hr or power less than 250 Watt.
- L2 category vehicles are two-wheelers other than L1 category
- L3 category vehicles are two-wheeled motorcycles with speeds exceeding 50 km/hr
- L5M/N category is defined as 3W passenger and load carriers (auto-rickshaws).
- Quadricycles are defined as L7
- followed by Passenger vehicle M1 to M3 and commercial and service vehicles N1 to N3.

All categories of vehicles except for low speed & power 2wheelers can be certified at ARAI. The complete details regarding vehicle types can be found here.

Laws, Rules and Regulations

For understanding the differences between the three categories, take an example of the hub of a vehicle that is to be made. Now, this is a major and critical moving part in the wheel of the vehicle.

Subjective description of a legal part/system/vehicle is done via law, guidelines, “directives” from government bodies or international independent agencies.

Law: A law is a system of rules created to ensure a certain behaviour/action by those who have to abide by it. Law will give rise to regulations. A law is defined in a very detailed manner which ensures that there is no misinterpretation.

Regulation: A regulation is made with a goal kept in mind. For example, in order to ensure safety for major moving parts like a hub in the wheel assembly, there can be a regulation to add a washer/jam nut instead of other types of fasteners. This will ensure that the goal is achieved by legally mandating an action. Everybody within a countries’ border must adhere to the regulations/actions required.

Directive: Directives define the goal that must be achieved and the time period for it. The concerned authorities are flexible to come up with a plan of action in order to achieve this goal. In the above example, it would mean that various bodies can come up with their own solution to ensure the safety of the wheel hub be it using jam nuts or other locking mechanisms

Eg: BIS Bureau Of Indian Standards, AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE

Standards

A technical standard is an established norm or requirement for a repeatable technical task. It is usually a formal document that establishes uniform engineering or technical criteria, methods, processes, and practices. In contrast, a custom, convention, company product, corporate standard, and so forth that becomes generally accepted and dominant is often called a de facto standard.

Standards are documents which mention certain values of measurement of various functionality a system/part should meet or surpass to be considered as a legal/valid unit. This also defines test procedures.

In order to come up with these standards, there are four parties involved in doing so. The ministry of road transportation under the government of India defines the laws i.e Central motor vehicle Rules (CMVR). A committee under the ministry of road transportation was set up called the Automotive Industry Standards committee which gave authority to organizations such as ARAI to publish and test for adherence to these standards for all vehicle manufacturers.

The AIS published are the standard procedures for certain tests required to conform to the CMVR national standards and be considered road legal.

Eg: AIS 039

Compliance

Compliance, as the name suggests, is the kind of testing done in order to determine if a certain product is functioning in the expected manner and meeting a threshold standard performance parameter. It is a win/loss situation, either a part/vehicle is compliant with the rule or it is not. The results are usually indisputable. For example, The drive shaft must have a certain minimum tensile strength. If the shaft has any lower than the specified amount, it will simply fail the compliance test (given that the test is done according to the standard).

In a commercial sense, this is done for satisfying customer ***requirements.*** A bare minimum value that must be met in order to consider the product for further testing which may pertain to the performance.

“Compliance” means matching to “the standard” is verified in “homologation” testing done at labs.

Homologation

The process to test a particular part, system, product whether it complies/conforms to relevant “standards” issued by relevant authorities is called Homologation.

The only approval required for a manufacturer to start selling their product is getting certified via homologation. The tests performed will be in a standard way in accordance with the CMVR and measure various parameters while checking for many safety aspects in the vehicle.

A manufacturer usually applies for homologation after performing pre-compliance tests multiple times.

Homologation is concerned with following the standard methodologies put forth by CMVR and performing these tests according to these standards:

- AIS-038 - Construction and functional safety standards
- AIS-039 - Measurement of electric energy consumption
- AIS-040 - Method of measuring the range
- AIS-041 - Measurement of net power and maximum 30-minute power
- AIS-048 - Safety requirement for traction batteries
- AIS-049 - CMVR type approval for electric vehicles

Why Homologation?

Homologation is necessary for any vehicle manufacturer to make its vehicles street legal. Passing these safety regulations will make the car legal to be driven on the road and at the same time, the efficiency tests will also determine important parameters such as mileage etc.

Homologation won't only help with the legality aspect but also help with the marketing of the vehicle. The customers will know of the important parameters that can greatly influence the buying decision for a potential customer.

It is however important to prepare for homologation since the very start of the product development phase. The homologation has high stakes both in terms of cost and time. The vehicle manufacturer should ideally perform multiple tests prior to homologation to ensure that the vehicle can get homologated in the first try itself.

Various Tests Involved for different components

Most of the test plans during this phase of homologation are from a case to case basis. The types of vehicles and also the BOM plays an important role in determining how many tests need to be performed and at a component level, which ones are supposed to be done.

1. Motor
    - Power test
    - Peak power test
    - Motor Mapping

- Continuous power test

2. Batteries

- Charge & discharge test
- Continuous charge and discharge test (degradation test)
- Ageing test
- Nail penetration test

Preparing for homologation

Pre-compliance testing

Pre-compliance is a low-risk, cost-effective method to ensure your device under test (DUT) will pass final compliance testing. Waiting until the end of a product development cycle for compliance testing is risky due to its high cost. The cost of compliance testing includes reserving time in the compliance lab and redesigning your DUT if it does not pass compliance. Proper pre-compliance testing is crucial if you want to save money and avoid surprises during compliance testing.

Pre-compliance testing is pivotal in reducing risks before going for the actual compliance testing process. It may cost a bit to verify the compliance in advance but the opportunity cost of not getting it tested beforehand is far higher than it.

R&D testing

This kind of testing is done usually at an earlier stage during the product development process. The product/part is still under development and various methodologies are used to optimize the product performance for a certain application. This is usually done before pre-compliance testing.

R&D tests will usually help the manufacturer learn about various pitfalls/faults they may have not caught during the prototyping/design phase of the product. This can help immensely in understanding not only the product performance but also the basic working and identify any anomalies in the product which can potentially save a lot of time and money for the manufacturer

Some of the most commonly required testing equipment for early-stage EV companies are the environmental chamber, cell & battery testing equipment and motor test bench. Micelio Studio lab has the above pieces of equipment available with many startups already availing the facility of these equipments for their R&D testing needs,

Functional Safety

Functional safety features form an integral part of each automotive product development phase, ranging from the specification, to design, implementation, integration, verification, validation, and production release.

Functional testing pertains towards the customer ***needs***, Functional testing will help the manufacturer understand the performance of the product/vehicle when it is subject to various conditions. These can be environmental, internal etc. For example, the speed at which a car can corner a particular radius before losing grip is a functional/performance parameter. There has to be a bare minimum grip provided by the tyre, however, pushing the vehicle to its limits to find out the performance output is also a major part

This also helps manufacturers with the marketing of their products. As they can claim some competitive parameters/metrics for alluring customers in the commercial markets. For example, marketing a vehicle for its fuel efficiency capabilities.

One major type of test that should be performed is the EMI/EMC test for the electronic components in the electric vehicle.

EMI Testing

EMI can be defined as electromagnetic energy which affects the functioning of an electronic device. Sources of EMI can sometimes be naturally occurring environmental events, such as electrical storms and solar radiation; but more often than not, the EMI source is another electronic device or electrical system. While EMI can be generated from any electronic device, certain equipment and components – such as cellphones, welders, motors and LED screens – are more likely to create disturbances than others.

Because it is rare for electronics to operate in isolation, products are generally engineered to function in the presence of some amount of EMI. This is particularly important in military-grade and avionics equipment, as well as devices requiring superior reliability in all situations.

EMC Testing (electromagnetic compatibility)

EMC is a measure of a device's ability to operate as intended in its shared operating environment while, at the same time, not affecting the ability of other equipment within the same environment to operate as intended. Evaluating how a device will react when exposed to electromagnetic energy is one component of this, known as immunity (or susceptibility) testing. Measuring the amount of EMI generated by the device’s internal electrical systems – a process known as emissions testing – is another.

Both aspects of EMC are important design and engineering considerations in any system. Failing to properly anticipate the EMC of a device can have a number of negative consequences, including safety risks, product failure and data loss. As a result, a wide range of testing equipment for EMC and EMI has been developed to give engineers a clearer picture of how a device will operate in

real-world conditions.

EMI/EMC Testing

Going for Homologation

Steps in the homologation process

- Component approval (lamps, mirrors, tires etc)
- Component fitting to the vehicle (electric/electronic sub-assemblies, car audio system etc)
- System approvals (breaking, exhaust emission etc)
- Whole vehicle type approval (WVTA) / Vehicle certification test.

For each item, the Indian authority chosen by the manufacturer will issue a system approval according to each applicable CMVR. Those approvals are based on test reports prepared by an officially recognized testing organization. Once all approvals are collected, the testing organization issues the report for the approval as a basis for the homologation certificate. This certificate is recognized in all Countries as mentioned in the test Report.

Approaching for homologation

In addition to the above, ARAI in collaboration with the Dept. of Heavy Industries has set up an exclusive E-Mobility platform where individuals can find data and information regarding different Govt. policies, standards, notifications, research capabilities and events. In addition, one can also use this portal to directly get in touch with the Automotive Electronics Dept. that works exclusively with EV related powertrains, electronics and electrical testing and certification.

In general, we recommend that vehicle manufacturers directly get in touch with the Homologation team (HMR) at ARAI as alternate non-EV testing may be required. Component manufacturers on the other hand directly approach the AED team for certification.

General Flow For Homologation

1. Submitting requirements, company identity, registration, PAN / TAN and authorised personals contact details.
2. Mail communication for quotes, process and on accepting - document submission as required with application and certification fees.
3. Compliance to required standards as per requirements, testing, validation.
4. Reports and certification are generally provided within 15 days of completion of all tests (in the case of vehicle level certification through HMR, these shall be submitted to HMR and not the manufacturer)
5. Certification, closure, billing

Points to note:

1. Formats are to be filled in carefully in order to reduce time, corrections and test failures. These entered values will be viewed as declared values and must coincide within said margins to test values if need be. This is more so for AIS 039, AIS 040 and 041.
2. As our customer, ARAI/ ICATT seeks to help, facilitate, guide and troubleshoot within limits where the DUT (Device Under Test) is failing. Customers are requested to accordingly co-operate and accordingly act. Communication is essential.
3. For details regarding necessary steps and procedure post-certification, please refer to the CMVR book. Further action will be required with RTO and Govt. agencies for vehicle registration and FAME benefits.
4. In case of any changes in company ownership, name, product name, model no or S.No, structure, product modifications, changes or more, please contact ARAI and confirm if re-certification is required or not.
5. In the event that a new test or standard is implemented, products sold thereon must be certified against it. (General ex: an EV battery sold in July 2023 must be certified as per AIS 156 rather than 048).

AIS standards - Automotive industry standards are the standards to be followed for getting vehicles approved to be considered street legal. Each category of vehicles has to follow a combination of these AIS standards in order to be cleared for consumer usage.

EV Standards

The following AIS standards are relevant for E-mobility/Electric vehicles space.

List of AIS Standards for EV

With respect to EV specific testing (electric powertrain and auxiliary equipment) and standards, these include:
1. AIS 004 Part 1 - 3 (EMI / EMC - power electronics - controllers, chargers and all auxiliary and electronic equipment)
2. AIS 038 Rev 1 (Safety test - vehicle level)
3. AIS 039 Rev 1 (Energy Consumption test - vehicle level)
4. AIS 040 Rev 1 (Range Tests - vehicle level)
5. AIS 041 Rev 1 (Power Tests - both vehicle and component level possible)
6. AIS 048 / 156 (Battery & Energy Storage - component level testing)

Special attention must be brought to AIS 156 which will be a replacing standard for AIS 048 after 2023. It includes enhanced testing for improved battery safety and performance. However, for the time being, AIS 156 remains an option beside 048 to customers.

In short:
1. Motor & Controller - AIS 004, AIS 041
2. Battery and safety systems - AIS 048, AIS 156 (optional alternate to AIS 048 - mandated, replaces 048 from 2023), parts of AIS 038.
3. Auxiliary Electrical, electronics and chargers - AIS 004 Part 3

The standards for retro fitment; conversion of vehicles to pure electric is AIS 123 (Part 3)

The standard for chargers is as AIS 138 (Part 1 &2)

Component level AIS standards for two-wheelers

1 Tyres: IS:15627 & AIS 037
2 Reflex Reflector: AIS 057
3 Horn : IS 1884 & AIS 037
4 Automotive lamps (bulbs) (Single/ Double Filament) : AIS 034 & AIS 037
5 Hydraulic brake hose (if applicable) : IS 7079 & AIS 037
6 Hydraulic brake fluid (if applicable) : IS 8654
7 Performance requirements for Lighting & Signalling devices : AIS 010 & AIS 037
7.1 Headlamp assembly (Glass lense) / (Plastic lense) : AIS 010 & AIS 037
7.2 Front / Rear Direction Indicator lamp assembly : AIS 010 & AIS 037
7.3 Front Parking lamp assembly: AIS 010 & AIS 037
7.4 Rear Registration Plate Lamp Assembly: AIS: 010 & AIS: 037
7.5 Rear Combination Lamp Assembly (with Stop/Tail, Direction Indicator lamps, Number plate lamp) : AIS 010 & AIS 037
8 Rear View Mirror Specifications : AIS 001 & AIS 037
9 Wheel rim : AIS 073 & AIS 037
10.1 Alloy Wheel Rim (Part I) : AIS 073 & AIS 037
10.2 Steel Wheel Sheet Metal(Part II) : AIS073 & AIS 037
10.3 Spoke Wheel Rim (Part III) : AIS 073 & AIS 037

Types of agencies

1. **Nodal Agency** - This agency reviews all the documents and prerequisites for the homologation process.
2. **Test Agency** - They will perform the actual physical tests of the vehicle for the safety approval

The testing agency conducts 9 tests for electric vehicles.

Other tests conducted for all vehicles

1. Braking
2. Mass emission/fuel efficiency
3. EMI/EMC
4. Requirements for construction and functional safety
5. Measurement of electrical energy consumption
6. Method of measuring range
7. Tell-tales and indicators
8. Gradeability at 7 degrees

Budgeting for Homologation

Companies can assume to budget in a 30% buffer amount from the expected homologation cost. This applies to all categories of vehicles. The approximate costs (in INR) for various categories of vehicles are as follows :

1. Low-speed two-wheelers (less than 25kmph): 3.5-4.5 L (Approximate figure on higher estimated side for entire homologation along with two vehicles and cost of assistance).
2. E-Rickshaws (25 kmph) : 7.5 L
3. High-speed two-wheelers: 12 L
4. 3 Wheelers: 26 L

Certifications from various agencies

CE

CE marking is an administrative marking that indicates conformity with health, safety, and environmental protection standards for products sold within the European Economic Area (EEA). The CE marking is also found on products sold outside the EEA that have been manufactured to EEA standards. This makes the CE marking recognizable worldwide even to people who are not familiar with the European Economic Area. It is in that sense like the FCC Declaration of Conformity used for selling certain electronic devices in the United States.
The CE marking is the manufacturer's declaration that the product meets EU standards for health, safety, and environmental protection.
The manufacturer is not required to get a product certified but usually, companies undergo testing and certification from third parties like Intertek, TUV to manage liabilities as a manufacturer if choosing to self declare the conformance is liable to any issue arising from the product later.

The mark consists of the CE logo and, if applicable, the four-digit identification number of the notified body involved in the conformity assessment procedure.
"CE" is sometimes indicated as an abbreviation of *"Conformité Européenne"* (French for "European Conformity") but is not defined as such in the relevant legislation. The CE mark indicates that the product may be sold freely in any part of the European Economic Area, irrespective of its country of origin.

BIS

The BIS (Bureau of Indian Standards) is the National Standard Body of India established under the BIS Act 2016 for the harmonious development of the activities of standardization, marking and quality certification of goods and for matters connected therewith or incidental thereto.

These standards pertain to the safety specifically the environmental safety hazards that certain products may pose such as Li-ion batteries. Hence many cells require BIS certification for being deemed safe to use in various applications or even sold to entities.

This registration is necessary for selling any product in the Indian market. This is required for parts being imported too. Incase of R&D samples for prototypes we can avoid BIS via declaration for R&D purposes but for serial manufacturing with significant volume, BIS is recommended.

UN38.3

Nearly all lithium batteries are required to pass section 38.3 of the UN Manual of Tests and Criteria (UN Transportation Testing). Li-ion batteries which are serial production units are required to have UN38.3 certificate for permission to be transported by air. If batteries do not have this they need to be shipped via sea which is time-consuming.
The following tests must be performed for getting Li-ion batteries certified for transportation :
T1 – Altitude Simulation (Primary and Secondary Cells and Batteries)- Here “pressure vent “ of battery and overall battery casing is testing if they behave safely in varying pressure cycle inside the aircraft
T2 – Thermal Test (Primary and Secondary Cells and Batteries) - This test assesses cell and battery seal integrity and internal electrical connections.
T3 – Vibration (Primary and Secondary Cells and Batteries)- This test simulates vibration during transport. Cells and batteries are firmly secured to the platform of the vibration machine without distorting the cells in such a manner as to faithfully transmit the vibration.
T4 – Shock (Primary and Secondary Cells and Batteries) - Test Cells and batteries shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of each test battery. Each cell shall be subjected to a half-sine shock of peak acceleration of 150 G and a pulse duration of 6 milliseconds.
T5 – External Short Circuit (Primary and Secondary Cells and Batteries) - Cells and batteries meet this requirement if their external temperature does not exceed 170 DC and there is no disassembly, no rupture and no fire during the test and within six hours after the test.
T6 – Impact (Primary and Secondary Cells) - Cells and component cells meet this requirement if their external temperature does not exceed 170°C and there is no disassembly and no fire during the test and within six hours after this test.
T7 – Overcharge (Secondary Batteries) - The charge current shall be twice the manufacturer's recommended maximum continuous charge current. The minimum voltage of the test shall be as follows:

(a) when the manufacturer's recommended charge voltage is not more than 18 V, the minimum voltage of the test shall be the lesser of two times the maximum charge voltage of the battery or 22 V.
(b) when the manufacturer's recommended charge voltage is more than 18 V, the minimum voltage of the test shall be 1.2 times the maximum charge voltage.
Rechargeable batteries meet this requirement if there is no disassembly and no fire during the test and within seven days after the test.
T8 – Forced Discharge (Primary and Secondary Cells) - Primary or rechargeable cells meet this requirement if there is no disassembly and no fire during the test and within seven days after the test.

FAME Subsidy for EV startups, consumers and manufacturers

Faster adoption and manufacturing of Electric & Hybrid vehicles (FAME) is a scheme launched by the government of India in association with NITI Ayog for facilitating the transition towards electric vehicles.

The FAME subsidy has 4 pillars:

1. Technology development
2. Demand creation
3. Pilot projects
4. Charging infrastructure

Phase I of FAME (Faster Adoption of Manufacturing of Hybrid and Electric Vehicles) launched in Mar-15 with an outlay of INR795 crore
FAME-I initially approved for 2 years starting from Apr-15 was further extended up to 31-Mar-19 Allocation of outlay of Rs. 795 crore further enhanced to Rs. 895 crore
Based on the experience of FAME-I and inputs from stakeholders DHI formulated Phase II of FAME (FAME-II)

The subsidies are aimed at both consumers and manufacturers. The demand side subsidies meaning the subsidies which aim to increase the demand for electric vehicles are structured in terms of the battery energy for each vehicle.

For example, there is an incentive of Rs 10,000/- per kWh energy of the battery for all vehicles other than buses and different amounts for other energy capacities.

The three pillars for FAME-|| are :

1. Demand Incentives
2. Establishment of a network of charging stations
3. Administration of Scheme including publicity

Common Challenges Faced During Homologation

1. Testing of an entire vehicle on a dyno is challenging due to its availability.
2. The budgeting for homologation also poses an issue at times. The companies may prepare for uncertainties in the total costs incurred during homologation.
3. Use of Chinese products in sub-systems which hinders the compliance testing as the standards are different in each country
4. Improper shielding/routing done for the wires
5. EMI/EMC issues and unsatisfactory grounding done
6. EMI / EMC - Emissivity - Throttle feedback and hall effect sensors failing, motor speed varies or just stalls.
7. EMI / EMC - Emissions - DC/DC converters & BMS
8. Isolation test
9. Penetration test on the battery (AIS 048, AIS 156 solves a few of these issues)
10. Thermal Runaway - AIS 038 R2
11. Overcharge, shock and vibration on cell and pack due to poor cell quality and battery packaging.

During Homologation

- All the reports of the pre-compliance tests will be checked and verified against a benchmark which is decided by the homologating committee
- If the values are found to be satisfactory, the actual test is conducted on the product to check it's actual performance with respect to the mentioned parameters
- After the certificate of homologation is received, the original prototype is preserved in perpetuity till the end of the life cycle in order to verify the mass-produced/actual part is the same at every design and functional level
- In the case of hub motors, there are two samples which are required during homologation. One of the prototypes must be mounted on a 2 wheeler/applicable vehicle and the other has to be an independent component

Monetary Aspects

- The part of prototyping, testing etc. are an indirect cost which helps mitigate the risk of having to go for homologation multiple times
- The prototypes are far more expensive than the actual product as they have to be manufactured using expensive processes such as laser cutting etc. The costs could go up to Rs 3L to 30L INR per prototype
- There are various environmental tests that are required to be performed that cost approximately 10-40L
- The EMI and EMC tests hold a significant amount of the total cost for the pre-compliance tests.

Sources

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Any querries related to Homologation within Indian Geography can be marked to

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